LESSONS LEARNED FROM COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES

Final Report

by

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PREFACE

The work presented in this document was conducted under the Investment and Management Decision Making Research Program. The Research Program is sponsored by the Headquarters, U.S. Army Corps of Engineers and is assigned to the Institute for Water Resources (IWR). Mr. Darrell Nolton is the Program Manager at IWR. Mr. Harry Kitch, Ms. Lillian Almodovar, and Mr. Bruce Carlson, all of the Planning and Policy Division, are the Headquarters' Program Monitors. Field Review Group Members that provide overall Program direction include: Mr. Ken Barr and Ms. Teresa Kincaid of the Rock Island District, Ms. Sharon Bond and Mr. Mitch Laird of the Louisville District, Ms. Beth Brandreth of the Philadelphia District, Mr. William Fickel of the Fort Worth District, Mr. Martin Hudson of the Portland District, Mr. Matt Laws of the Charleston District, Mr. Richard Medina of the Galveston District, Mr. Gerald Melton of the South Atlantic Division, Mr. Craig Seltzer of the Norfolk District, Mr. Dan Sulzer of the Los Angeles District, Mr. Carl Swor of the Nashville District, Mr. Jeff Trulick of the Baltimore District, Mr. Francke Walberg of the Kansas City District, Mr. Paul Wemhoener of the Omaha District. This report was prepared under the general supervision of Mr. Ken Orth, Chief of the Decision Methodologies Division, IWR, and Mr. Rob Pietrowsky, Director of IWR. Ms. Beth Brandreth of the Planning Division, Philadelphia District, and Mr. Leigh Skaggs of Decision Methodologies Division of IWR authored this document.

The proposal to look for lessons learned from the Corps' experience with cost effectiveness and incremental cost analyses was developed by Mr. Ken Orth, Chief of Decision Methodologies Division of IWR. Mr. Orth initiated and guided the initial study effort. The authors wish to thank the following individuals of the Headquarters Planning and Policy Division for their assistance in providing and selecting planning reports to review: Mr. Mark McKevitt, Mr. Terry Breyman (both now of the Office of the Assistant Secretary of the Army (Civil Works)), and Ms. Susan Ragon. The authors also thank the following individuals for providing valuable review comments: Mr. Mark McKevitt of the Office of the Assistant Secretary of the Army (Civil Works); Ms. Lillian Almodovar of Planning and Policy Division, Headquarters; Mr. Mark Colosimo of Planning and Policy Division, Headquarters; Mr. Bruce Carlson of Planning and Policy Division, Headquarters; and Mr. Ken Orth, Mr. Darrell Nolton, and Ms. Lynn Martin of IWR.

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INTRODUCTION

Since the introduction of the requirement to conduct cost effectiveness and incremental cost analyses, many such analyses have been conducted throughout the Civil Works District offices of the U.S. Army Corps of Engineers (Corps) for a variety of different projects. Methods of implementation have varied greatly, however, among the various Corps Districts and among different types and sizes of projects (e.g., between mitigation and ecosystem restoration, and between large and small projects). The goals of this report are to examine some of the analyses done to date and to determine how the regulations are being interpreted and applied, whether recurring problems exist, and if further guidance or instruction (in the form of new procedures, manuals or training, for example) is needed to streamline or simplify the process. This report also looks at the effectiveness of the analyses and the existing tools available in order to determine if the procedures are working, if the analyses are being done correctly, and if they provide better information and results through their implementation. In other words, what lessons have we learned from performing cost effectiveness and incremental cost analyses over the last decade?

BACKGROUND

In accordance with Federal guidance and guidelines, benefit-cost analyses and cost effectiveness and incremental cost analyses have long been integral components of the Corps' water resources and environmental planning. Prior to the mid-1980's however, these analyses primarily focused on projects' monetary costs and benefits. Beginning in 1983, with the adoption of the Principles and Guidelines (U.S. Water Resources Council 1983), the Corps started to apply the principles of incremental cost analysis to the mitigation of fish and wildlife habitat losses. These requirements have been further defined for Corps projects by Engineer Regulation 1105-2-100 (U.S. Army Corps of Engineers 2000) which states:

> "An incremental cost analysis shall be performed for all recommended mitigation plans. The purpose of incremental cost analysis is to discover and display variation in costs, and to identify and describe the least cost plan."

In addition to their application for mitigation planning, cost effectiveness and incremental cost analyses are also required under current Corps program and planning guidance with respect to ecosystem restoration. The Corps has incorporated ecosystem restoration as a primary project purpose within its Civil Works program in response to increasing National emphasis on environmental restoration and preservation. Ecosystem restoration can be considered as a single purpose project or as part of a multiple purpose project in conjunction with navigation, flood damage reduction and other purposes. Ecosystem restoration projects are formulated to restore the structure, function, and dynamic processes of degraded ecosystems. Activities that concentrate on restoration opportunities associated with wetlands, riparian, or other floodplain and aquatic systems are likely to be most appropriate for Corps involvement (U.S. Army Corps of Engineers 1999 & 2000). Ecosystem restoration projects can be individually authorized or pursued under the Continuing Authorities Program (CAP). They can stand alone or be linked to modifications of the operation or structure of existing Corps projects, such as the beneficial use of dredged material, modification of dam operations, removal of features impeding anadromous fish passage, and water quality improvements through redesign of water control structures.

Regardless of the project's authority, funding, or components, all Corps projects must be justified. Whereas for such traditional Corps project purposes as navigation and flood damage reduction the benefits are monetized and alternatives are evaluated through benefit-cost analyses, for ecosystem restoration projects the benefits are not monetized and alternatives are evaluated through cost effectiveness and incremental cost analyses (U.S. Army Corps of Engineers 2000).[1]

[1] In addition to cost effectiveness and incremental cost analyses, according to Corps Planning Guidance (ER 1105-2-100) other criteria used to evaluate and ultimately select among ecosystem

In order to comply with the requirements of the Corps Planning Guidance, ER 1105-2-100, a cost effectiveness analysis must be conducted for mitigation and ecosystem restoration projects to identify the least cost solution for each possible level of environmental output. A solution is defined as cost effective when, for a given level of output, no other alternative plan has a lower cost. Similarly, a solution is cost effective when no other alternative plan yields more output for the same or less cost. An incremental cost analysis must then be conducted on the cost effective solutions to identify changes in costs for increasing levels of environmental outputs. Incremental cost analysis examines the subset of cost effective plans sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental outputs. These most efficient plans, called “Best Buys,” provide the greatest increases in output for the least increases in cost and have the lowest incremental costs per unit of output (U.S. Army Corps of Engineers 2000).

Incremental cost analysis is a tool that can assist in the plan formulation and evaluation process while helping to identify and display variations in cost among different increments of restoration measures and alternative plans. Use of incremental cost analysis helps decision makers determine the most desirable level of output relative to costs and other decision criteria. It is expected that these analyses will be performed at an appropriate level of detail for each study in order to identify multiple cost effective plans within the identified constraints (U.S. Army Corps of Engineers 2000). In evaluating, comparing, and ultimately selecting among alternative plans, planners must ask whether the successive levels of incremental output are "worth" their incremental costs. ER 1105-2-100 states that the ecosystem restoration plan should be recommended "…where the incremental beneficial effects just equal the incremental costs, or alternatively stated, where the extra environmental value is just worth the extra costs" (Appendix E, E-28.e.(i)). Due to the absence of a common unit of measure for comparing monetary costs and non-monetary benefits for environmental plans, cost effectiveness and incremental cost analyses can help in framing and answering these questions.

Early applications of the incremental cost analysis guidance frequently consisted of an intuitive calculation and display of the *average* cost per unit of environmental output ("benefit") for a set of alternative plans. This approach did not provide a good measurement of the incremental costs and benefits associated with alternative plans. In order to help planners perform a more acceptable and defensible analysis, the Corps’ Institute for Water Resources (IWR) was tasked with developing procedures to accomplish cost effectiveness and incremental cost analyses (U.S. Army Corps of Engineers 1994a). In response to this task, IWR developed several implementation and

restoration alternatives include significance of outputs, acceptability, completeness, efficiency, effectiveness, risk and uncertainty considerations, partnership context, and reasonableness of costs.

demonstration manuals[2], followed by the introduction of an incremental cost analysis software program. The program, which has evolved from the DOS-based ECO-EASY format to a newly updated Windows-based format called IWR-PLAN Decision Support Software, is capable of combining user-provided measures or solutions into alternative plans and comparing alternative plans while conducting cost effectiveness and incremental cost analyses.

[2] IWR Report 93-R-16 (Bussey Lake: Demonstration Study of Incremental Analysis in Environmental Planning); IWR Report 94-PS-2 (Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps); and IWR Report 95-R-1 (Evaluation of Environmental Investments Procedures Manual Interim: Cost Effectiveness and Incremental Cost Analyses).

METHODS

In order to gather information from completed cost effectiveness and incremental cost analyses (CE/ICA) for this report, a total of 32 Corps project reports were initially reviewed. The reports were chosen from a list of approved reports obtained from the Headquarters (HQUSACE) Planning and Policy Division. The original list contained hundreds of reports dating from 1988 to the present and included all documents subject to HQUSACE review. A review of this list identified approximately 133 reports that had ecosystem restoration or environmental mitigation components. In order to reduce the size of this list and ensure the diversity of the data collected, the reports chosen for review were based on project size, date, purpose, and location, as well as the availability of the report itself. As a result, 32 reports were reviewed, consisting of projects dating from 1994 to the present, which span 18 Districts, and range in size from Section 1135 projects[3] to large flood damage reduction projects. The reports reviewed were obtained from the document library managed by the Planning and Policy Division staff.

A preliminary review of the 32 reports was conducted to confirm the use of CE/ICA in the reports. The results of this preliminary review led to the elimination of six ecosystem restoration reports that did not include any form of an identifiable CE/ICA. The 26 remaining reports were then subject to a more detailed review with a focus on the CE/ICA aspects of the project. Three of these 26 documents, upon further review, were found to have a reference to CE/ICA within the report but the actual analysis had not been conducted. Document review questionnaires, developed for this study, were completed for each report in order to answer specific questions relating to the CE/ICA. A sample of the questionnaire used can be found in Appendix A. Specific data collected during the review included:

- cost of the selected plan
- number of management measures identified
- consideration of relationships such as *dependency* (a management measure that requires or depends on another) and *combinability* (a measure that may be combined to work in concert with another)
- type of output units (e.g., acres, habitat units, population counts)
- number of output units of the selected plan
- use of software to conduct CE/ICA
- number of alternative plan combinations

[3] Section 1135 of the Water Resources Development Act of 1986 authorized the Corps to review existing projects to determine the need for modifications that would help improve the quality of the environment. These modifications can be to the physical infrastructure itself or to the project operation. Section 1135 Project Modifications for Improvement of the Environment are managed as a Continuing Authority Program and have a $5 million Federal cost per project limit.

- use of graphs or displays to present the results of analyses
- reasons for recommendation of the selected plan

The review also considered the level of detail of the CE/ICA, how closely the analysis followed the guidance, if the results of the analysis were used for selection of the recommended plan, and what problems or difficulties were encountered during the course of the analysis.

In order to further diversify the type of projects reviewed for this report, several other government agencies were contacted with regard to their use of CE/ICA. These agencies had expressed a past interest in the use of IWR's automated CE/ICA software and were therefore asked about such use. While some agencies had used the software for training or informational purposes, no projects using CE/ICA had been completed by the individuals contacted and therefore no reports were available for review during this study.

Following the review of the reports, several personnel from Corps district offices who had completed CE/ICA were contacted. The objective of these personal interviews was to determine their impressions of the usefulness, applicability, and accuracy of the analyses and to discuss problems they may have encountered which hindered the analyses. Suggestions for future training needs, ideas for improvement, and general comments were also solicited.

PROJECT REPORT SUMMARIES

One of the goals of this study was to identify recurring problems that are being encountered during the implementation of CE/ICA in order to gain insight and "lessons learned" that could be shared with other study teams grappling with some of the same issues. While project reports are discussed in this document in order to identify some of the problems encountered during the analyses, individual projects and Districts are not specifically identified. All 26 projects discussed throughout this report were found to contain references to a CE/ICA during the preliminary review and were kept in the analysis despite the fact that, upon further review, it was discovered that several projects did not actually complete the cost effectiveness and incremental cost analyses. All projects are identified by a letter code (A through Z), not by project name, and are grouped according to project authority. The titles of the reports reviewed are included in the reference section solely for the purpose of acknowledgement.

Using some of the information gathered during the report reviews, the following project summary information is presented in order to familiarize the reader with the 26 projects that will be discussed in the *Results* section of this document. Some of this information, as well as additional project details not included in these summaries, can be found in Table 1 at the end of this section.

General Investigation[4] Ecosystem Restoration Studies

Project A. This project was a flood damage reduction study with ecosystem restoration and mitigation components. The purpose of the ecosystem restoration was to develop a wetland complex that would provide the maximum wetland and related deep water and grassland habitat gains in a cost effective manner. Seven cells were evaluated for restoration and a CE/ICA was done "to assist in determination of whether the plan that maximizes total habitat output (the plan with all seven cells) is cost effective, and based upon its incremental cost, should be supported as the recommended environmental restoration plan". A total of 20 alternative combinations were evaluated. Non cost-effective plans were eliminated. An incremental cost analyses was performed on the cost effective plans, and the best buy plan[5] that maximized the environmental outputs (184 Average Annual Habitat Units (AAHU's)) was chosen as the selected plan.

The mitigation component of this study was required to compensate for impacts which would result from the implementation of the flood damage reduction portion of the project, (loss of various forest and grassland cover types). Three plans were evaluated to

[4] General Investigation (GI) studies are generally individually authorized studies that focus on a specified geographic area.
[5] Best buy plans are a subset of cost effective plans. They are most efficient in production, producing the greatest increases in output for the least increases in cost (i.e., lowest incremental cost per unit of output).

satisfy the mitigation needs, but only one plan would fully compensate for the impacts and meet the mitigation goals. As a result, this plan was chosen.

Project B. This project was a General Investigation (GI) ecosystem restoration study that evaluated 13 different sites within one watershed for fish and wildlife habitat restoration. All of these sites were evaluated separately and the number of alternatives for each site ranged between three and 31. Site specific alternatives were combined for one of the 13 sites, but the alternatives at all other sites were mutually exclusive. The selected plan included restoration of all 13 sites and consisted of the restoration of tidal and non-tidal wetlands, several streams, and a bottomland hardwood forest. The components that made up the selected plan were chosen because they maximized the output at each site in a cost effective manner and represented a best buy plan for 11 of the 13 sites. The selected plan resulted in a total output of 604 Habitat Units (HU's).

Project C. This project was a GI ecosystem restoration study that evaluated restoration alternatives at seven sites in order to restore aquatic and terrestrial habitat that had been degraded as a result of acid mine drainage. All seven sites were evaluated separately with each site having only one or two possible restoration alternatives. The selected plan consisted of restoration at all seven sites with outputs being measured in acres of habitat restored and acid load reduction. The reasons for selecting the recommended plan at each site varied but included: utilized "preferred" treatment method, maximized acid load reduction, reduced operational costs at neighboring site, and most cost effective.

Project D. This project was a GI ecosystem restoration study that evaluated restoration alternatives at five lake and pond sites with a goal of restoring and enhancing various habitat values (plant communities and associated fish and wildlife species). Each of the five sites had between two and four alternatives associated with it, and when the sites and their alternatives were combined, they produced a total of 1200 alternative combinations. The selected plan was one of the nine best buy plans identified and produced a total output of 76.13 AAHU's. The selected plan included restoration at all five sites and was chosen because it restored the greatest number of acres, produced the greatest number of HU's, was supported by the sponsor, was cost effective, and supported the restoration goals.

Project E. This project was a GI ecosystem restoration study with the goals of developing wetland restoration alternatives that incorporated the use of dredged material and the reuse of an army base. Nine alternative combinations at the army base site were initially identified. These alternatives included natural sedimentation versus use of dredged material and the utilization of different parcels of land. Four of these alternatives did not meet planning objectives and were dropped from the analysis. Other plans, which were later identified as cost effective, were also dropped from the analysis for not meeting planning objectives, while non-cost effective plans were returned to the analysis. The selected plan maximized environmental benefits, was most consistent with regional plans, and obtained restoration benefits quickly. The plan consisted of wetland restoration through the use of dredged material and produced an output of 17,019 HU's while restoring 570 acres of wetlands.

Project F. This project was a wetland demonstration project that evaluated the use of dredged material to restore, protect, and expand specific wetlands in a tidal estuary for the purposes of preserving waterfowl, fish, and other wetland-dependent species and to provide flood control, water quality improvements, and sedimentation control. The alternatives investigated included wetland restoration options at the site ranging in size from 17 to 348 acres. The selected plan was the chosen alternative because it met the goals of the specific project authority and had the lowest cost per acre restored. The selected plan resulted in the restoration of 289 wetland acres and a gain of 3,683 HU's.

Project G. This project was a GI ecosystem restoration study that evaluated the re-establishment of anadromous fish runs upstream of several existing Corps dams. Five acceptable alternatives were initially combined to produce a total of 32 possible alternative plan combinations. Combinations that did not meet the planning objectives were dropped from the analysis. Only five alternatives remained following this screening. The selected plan, which included juvenile salmon collectors and temperature modifications to the fish ladders, was a best buy plan that produced an output of 3,760 adult salmon returned to the area above the dams. The selected plan had the lowest cost of the best buy plans identified and was chosen because it met the planning objectives, while the next plan on the best buy curve was considerably more expensive with little gain in outputs.

Project H. This project was a GI ecosystem restoration study that evaluated the modification of the temperature of downstream releases from Corps projects in order to replicate pre-project temperature conditions. The objectives of the temperature modification included an increase in the number of annual salmon, the re-establishment of suitable temperature ranges for bull trout, and the re-establishment of habitat conditions favorable to native trout species. Four alternatives were evaluated in order to meet these goals. The selected plan, which consisted of the installation of a selective withdrawal system at two existing intake towers, was chosen because it maximized the number of annual adult salmon returns at a low marginal cost per returning adult salmon. The selected plan resulted in an estimated 16,700 annual adult salmon returns.

Project I. This project was a GI ecosystem restoration study that focused on the restoration and protection of habitat values associated with an interior tidal marsh and its associated shoreline fish and wildlife communities. Four alternatives were evaluated that were combined to form a total of eight potential restoration plans for the site. The selected plan consisted of a combination of alternatives and included a beachfill with interior tidal marsh restoration and the construction of a stone revetment. The selected plan, the alternative that had the lowest cost per habitat unit and met the planning objectives, produced a total of 193 AAHU's.

Project J. This project was a GI ecosystem restoration study that evaluated the restoration and protection of a freshwater wetland system in a coastal environment with incidental flood damage reduction benefits to the surrounding communities. The project investigated seven restoration alternatives for the site that, when combined, produced a total of 25 alternative plan combinations. The selected plan was a best buy plan which provided project outputs of 429 AAHU's. The selected plan consisted of invasive plant control, hydrology improvements, wetland restoration, and beach restoration.

Project K. This project was a flood damage reduction study that included recreation and ecosystem restoration components. The project investigated five grassland conversion alternatives and four riparian forest management alternatives along four river segments. IWR-PLAN was utilized during the CE/ICA and aided in the combining of alternatives, resulting in 100 alternative plan combinations for the grassland conversion component and 31 alternative plan combinations for the forest management component. The selected plan included a best buy plan for the grassland conversion component and a best buy plan for the riparian forest management component along the four river segments, resulting in a total gain of 117.27 AAHU's.

Project L. This project was a GI ecosystem restoration study that focused on restoring water to the flows of river bends and creeks in the project area to conditions approaching those that existed in the area prior to their degradation. Three alternative sites were evaluated for the restoration, each of which consisted of between one and eight components, resulting in 36 combined alternative plans. Plan components included large and small channel diversions, a full closure restoration channel, and a full closure navigation channel. Further screening and plan refinements reduced the number of potential plans to eight. Five best buy plans were identified but three were dropped from consideration because the District did not support them for various reasons (plans failed to meet certain planning objectives or provided less output than the next largest alternative in one of the two output categories). The selected plan resulted in project outputs of 1,067 AAHU's and 1,960 Bottomland Hardwood (BLHW) functional values.

Project M. This project was a GI ecosystem restoration study that focused on the rehabilitation and enhancement of waterfowl and fishery habitat within the project area (a single marsh complex). Eleven alternatives were evaluated for the restoration (each alternative equated to a separate management measure component) but only two alternatives had more than one "size" associated with it. The incremental analysis was only performed on these two alternatives, in order to determine which size would be combined with the other alternatives. The size with the lowest average cost was chosen for these two alternatives. Three of the eleven alternatives were mutually exclusive, two alternatives did not meet planning objectives, and another was determined to be unfeasible from an economic and environmental standpoint. The selected plan consisted of four of the 11 alternatives and included sediment trap creation, hydraulic dredging, pothole creation and a managed marshland. A HEP and a Wildlife Appraisal Guide

(WHAG) were used to quantify the outputs associated with the selected plan (638 AAHU's). These outputs represented increased migratory waterfowl and fisheries habitat through the creation of 32 acres of aquatic and wetland habitat.

Project N. This project was a GI environmental restoration study that focused on improving and increasing fish and wildlife habitat values and diversity while evaluating potential benefits for flood damage reduction, recreation, and water quality and supply. Six alternative plans, each composed of six different management measures, were evaluated for the restoration within the riparian corridor, resulting in 32 alternative combinations associated with each alternative. Management measures considered included installing pumps, various water distribution configurations, wetland creation at various sites of various configurations, dredging to create open water in various locations, exotic species removal, and restoration of riparian corridors. IWR-PLAN software was utilized in combining measures to form alternative plans and in identifying cost effective and best buy plans. A best buy plan was selected as the recommended plan. The selected plan was chosen because it restored a maximum amount of diverse habitat types and outputs (623 AAHU's) and provided maximum flood damage reduction.

Project O. This project was a GI ecosystem restoration project that evaluated restoration alternatives at four different restoration sites. The selected plan consisted of restoration at all four sites and included invasive plant removal, stream modification, lagoon dredging, the installation of storm management structures, and wetland construction. A HEP analysis was conducted for the project which indicated that the selected plan would provide 44.61 AAHU's over the without project conditions. While incremental increases in outputs were discussed, a CE/ICA was not completed for this project.

Section 1135 Studies

Project P. This project was a Section 1135 ecosystem restoration study which focused on identifying ecosystem degradation caused by the construction of a Corps reservoir project and evaluating measures to restore bottomland hardwood, wetland, and waterfowl habitats. Five locations were identified for restoration activities. The number of alternative measures identified for each site ranged between four and nine with the number of combined plans available for each site ranging from nine to 124. Habitat unit (HU's) values for this study were based on habitat type, rather than a specific species. The selected plan included restoration at all five sites and resulted in an output of 18,250 (AAHU's). The selected plan represented the combination of cost effective alternatives for each site that provided the greatest increase in habitat value for each site.

Project Q. This project was a Section 1135 ecosystem restoration study that investigated the restoration of degraded riverine and floodplain ecosystem structures, functions, and processes to achieve historic ecological conditions. Two alternatives were evaluated for the degraded area and the selected plan was chosen as the alternative with the lowest cost per acre. The selected plan consisted of channel excavation and dike removal. The Wildlife Habitat Appraisal Guide (WHAG) and the Aquatic Habitat Appraisal Guide (AHAG) were used to measure the outputs for the selected plan. A CE/ICA, while referenced in text of the document, was not completed for this project.

Project R. This project was a Section 1135 ecosystem restoration study that evaluated restoration alternatives for a marsh and a lake within the project area. The lake and the marsh areas were evaluated separately for the study. Alternatives for the marsh restoration included three different marsh sizes. The outputs for the marsh were surface area (acres) and volume (acre-feet), with the selected plan being chosen based on the cost per acre of the restoration alternative. The benefits for the lake were judged on what features would show a change in habitat values. These benefits included an increase in pounds of fish standing crop and increased spawning and feeding habitat.

Project S. This project was a Section 1135 ecosystem restoration study that focused on alternatives to restore wetlands that were drained after the construction of a canal, as well as alternatives to improve the quantity and quality of riverine fish and wildlife habitat. Four alternatives, each made up of between 11 and 13 components, were evaluated during this study. The components included moving levees, plugging drainage ditches, and installation of water control structures. The selected plan, which consists of diverting water flow from the canal to a natural river and three water control structures, was chosen because it maximized the environmental benefits. The outputs identified for the project included 1,096 acres of inundated wetlands, 48,900 linear feet of uninterrupted riverine habitat, the restoration of flow velocities, and an increase in the number of wading birds expected to utilize the project area.

Project T. This project was a Section 1135 ecosystem restoration study. The restoration was focused on the desire to improve the water quality of a lake that had previously been a borrow area for the construction of a Corps dam. Five alternatives were evaluated for restoration, and these alternatives were combined to form a total of nine potential alternative combinations. The selected plan was a best buy plan that produced an output of 1,799 Kg of fish biomass. The selected plan, which included passive inflow and a meter outlet with aerator, was chosen because it was subjectively determined that the benefits of the aeration component were worth the additional cost.

Project U. This project was a Section 1135 ecosystem restoration study that focused on maximizing the restoration of habitat for native endangered water birds. Five alternative pond configurations and locations were evaluated and, when combined with the various restoration methods, resulted in a total of 24 alternative combination plans. Three of the six best buys were carried through the analysis and the selected plan was chosen because it provided a unique habitat and had better maintenance access over the plan below it (i.e., less output) on the best buy curve. The selected plan included the construction of four ponds and increased the wildlife productivity of the project area by 1,310 birds per acre.

Project V. This project was a Section 1135 ecosystem restoration study that focused on restoring estuarine habitat and fish passage, as well as improving upstream fish habitat within the project area. Eight alternatives were identified as potential restoration options. The selected plan consisted of excavation, channel creation, wetland creation, and the removal of a culvert to aid in fish passage. Weighted environmental benefits provided the output for the study. The weighted index included such values as primary productivity, mean patch size, total edge, patch richness density, and diversity and interspersion indices.

Mitigation Studies

Project W. This project evaluated the feasibility of modifying the operations of two dams for water conservation purposes. The dam modifications were expected to require mitigation as a result of impacts to riparian and alluvial scrub habitats. Habitat values were quantified as HU's to represent the environmental impacts and outputs. Mitigation alternatives were evaluated for both habitat types and both locations, resulting in a total of 11 alternatives. Some of the riparian alternatives evaluated could not meet the mitigation goals as stand alone alternatives and therefore needed to be combined in order to achieve the proper amount of mitigation. The selected plan was a combination of alternatives and was chosen because it met the mitigation goals. Although some "increments" of alternatives were examined, no real CE/ICA, in terms of evaluating incremental costs and outputs, was performed.

Project X. This project was a flood damage reduction project with a mitigation component. The restoration of four different habitats (riparian forest, grassland, oak forest, and lacustrine) was evaluated at six sites. Each habitat type had two to three restoration increments at different "levels of intensity". For example, for one habitat type, the low intensity alternative consisted of land acquisition, the medium intensity consisted of land acquisition and planting 100 shrubs/acre, and the high intensity consisted of land acquisition and planting 200 shrubs/acre. Each level of intensity equated to a set of management measures, i.e., an alternative for that site. Only the highest level of intensity at each site produced enough outputs to satisfy the mitigation requirements, however. Therefore, the highest level of intensity was selected for each site since full compensation could only be achieved by selecting that plan.

Project Y. This project was a flood damage reduction project with a mitigation component. Seven mitigation sites, each with three different levels of resource management activities, were initially identified to accomplish the mitigation. Only eight of these 21 alternative site and scale combinations met the mitigation goals, however, so some of the alternatives were combined with each other in order to achieve the required goals. Once alternatives were combined, an additional 20 plans met the mitigation goals. Three cost effective combined alternatives were subsequently removed from the analysis due to potential real estate availability problems with the proposed mitigation site and three non-combined plans were then identified as cost effective. Of these, the alternative with the lowest total cost that met the mitigation goals was chosen as the selected plan.

Project Z. This project was a bridge replacement study with a mitigation component. Four alternatives were initially identified to complete the mitigation aspect of this project. Two of these alternatives were initially determined to be unfeasible, leaving only two potential solutions. One solution, which consisted of the creation of new wetlands, provided twice the amount of HU's required to compensate for the project impacts. The second alternative consisted of wetland restoration at eight sites and provided enough HU's to adequately meet the mitigation requirements. The restoration of the eight sites was the lowest cost alternative and was chosen as the selected mitigation plan.

As indicated in Table 1, the costs of the 26 projects reviewed varied greatly, as did the number and type of outputs measured. Project costs ranged from $300,000 for the mitigation component of a bridge replacement project to $97.6 million for a GI ecosystem restoration project. Habitat Units (HU's) and Average Annual Habitat Units (AAHU's) were the most common measure of environmental output, used in about two-thirds of the projects reviewed. In addition, while multiple output types were fairly common in the reviewed reports, 19 of the reports measured only one type of output. Seventeen of the reports contained combined management measures or alternative plans, with the number of combinations ranging between three and 1200. Despite the usefulness of utilizing graphs to display information, only ten projects used graphs to illustrate CE/ICA information relating to the cost effective and best buy plans. Eight projects used a computer software decision support tool (either IWR-PLAN or ECO-EASY) to aid in the analyses. Some correlation can be seen between the use of software and the use of graphs since 75% of the reports utilizing decision support software also used graphs and 60% of the reports utilizing graphs also utilized the software. Fifty-four percent of the reports indicated that the selected plan was a cost effective or best-buy plan.

Table 1
Project Report Information Summaries

Project Letter Code	Type	Total Cost (Millions)	# of Outputs (Selected Plan)	Output Units	Mgt. Measure Depend-encies?	Alternatives Combined?	# of Combin-ations	Graphs Used?	Soft-ware Used?	Selected Plan Cost Effective or Best Buy?
A	FDR & ER	$ 119.2 (Tot) $ 10.1 (ER)	184	AAHU's	Yes	Yes	20	No	Yes	Yes
B	ER	$ 18.8	604	AAHU's	No	Yes, for 1 out of 13	Varied 3-31	No	No	Yes, for 11out of 13
C	ER	$ 33.1	640 Reduced	Acres Acid Load	Yes	No	N/A	No	No	N/A
D	ER	$ 3.5	76.13	AAHU's	Not clear	Yes	1200	Yes	No	Yes
E	ER	$ 55.1	17,019	HU's	No	No	N/A	Yes	No	No
F	ER	$ 7.6	289	Acres	No	No	N/A	No	No	N/A
G	ER	$ 8.1	3,760	Adult Salmon	No	Yes	32	Yes	No	Yes
H	ER	$ 5.1	16,700	Salmon/yr	No	Yes	4	No	No	N/A
I	ER	$ 7.5	193	AAHU's	No	Yes	8	Yes	Yes	Yes
J	ER	$ 15.5	429	AAHU's	Yes	Yes	25	Yes	Yes	Yes
K	FDR & ER	$ 18.3 (Tot) $ 1.9 (ER)	117.27	HU's	No	Yes	131	Yes	Yes	Yes
L	ER	$ 3.4	1067 1960	AAHU's BLHW	No	Yes	36	No	No	Yes
M	ER	$ 3.9	638 32 38	AAHU's Acres Acre-Feet	No	Yes	Not clear	No	No	N/A
N	ER	$ 97.6	623	AAHU's	Yes	Yes	96	Yes	Yes	Yes
O	ER	$ 7.8	44.61	AAHU's	N/A	N/A	N/A	N/A	N/A	N/A
P	1135	$ 2.1	18,249.8	AAHU's	Yes	Yes	241	No	Yes	Yes

Table 1 (Continued)

Project Letter Code	Type	Total Cost (Millions)	# of Outputs (Selected Plan)	Output Units	Mgt. Measure Depend-encies?	Alternatives Combined?	# of Combin-ations	Graphs Used?	Soft-ware Used?	Selected Plan Cost Effective or Best Buy?
Q	1135	$ 3.6	2968	AAHU's	No	No	N/A	No	No	N/A
R	1135	$ 2.8	50 Increased Increased	Acres Acre Feet Pounds	No	No	N/A	No	No	N/A
S	1135	$ 4.9	1096 48,900 4129	Acres Wetlands LF Riv Hab Birds	No	No	N/A	No	No	N/A
T	1135	$ 0.9	1799	Kg of Fish Biomass	No	Yes	9	Yes	No	Yes
U	1135	$ 6.1	1310	Birds/Acre	No	Yes	24	Yes	Yes	Yes
V	1135	$ 3.2	84.82	WI	No	No	N/A	No	No	Yes
W	Mit	$ 11.7 $ 2.2 (Mit)	76	HU's	Yes	Yes	N/A	No	No	N/A
X	Mit	$ 2.8 (Mit)	658	HU's	No	Yes	12	Yes	Yes	Yes
Y	Mit	$ 2.4 (Mit)	25.9	HU's	No	Yes	28	No	No	N/A
Z	Mit	$ 15.2 $ 0.3 (Mit)	100.7	HU's	No	No	N/A	No	No	N/A

Legend

Project Type:	ER	GI Environmental Restoration	**Output Unit:**	AAHU's	Average Annual Habitat Units
	FDR	GI Flood Damage Reduction		HU's	Habitat Units
	Mit	Mitigation		WI	Weighted Index
	1135	Section 1135		LF Riv Hab	Linear Feet of River Habitat
				BLHW	Bottomland Hardwood Functional Units

RESULTS

As discussed in a previous section, an effort was made to ensure a diverse selection of projects for inclusion in this report. The types of projects containing CE/ICA that were included in this review were Section 1135 ecosystem restoration, general investigation (GI) ecosystem restoration, and environmental mitigation. It must be noted however that there is not an equal distribution of these types of projects being conducted throughout the Corps. For this reason, reviewing an equal number of the different types of projects would not have been practical, or desired, for this investigation. Of the 26 projects reviewed, 15 were GI ecosystem restoration projects, 7 were Section 1135 ecosystem restoration projects, and 4 had environmental mitigation components. One project was a floodway extension project that had both ecosystem restoration and mitigation components.

Mitigation Studies

Despite the fact that the requirement to perform CE/ICA for mitigation projects has been in place the longest, these studies seem to be where many of the recurring problems are occurring in the reports reviewed for this effort. This may be due to the constraints associated with meeting mitigation requirements or targets. For example, it may be more difficult to formulate a range of mitigation alternatives in a particular study area when mitigation requirements and/or recommendations include the need to replace a predetermined amount or type of habitat, or habitat units (HU's), often in specific locations. This replacement is always subject to much scrutiny by other Federal and State resource agencies in terms of habitat value and quantity, and by Corps higher authority in terms of cost. Achieving a balance between the two can be problematic. As a result, these difficulties and constraints have been carried over into the application and results of the CE/ICA.

One of the most common problems identified during this investigation was that mitigation plans that did not meet the stated mitigation goals were being used for the CE/ICA, and even carried through the analyses as best buy plans. In most cases, the formulation of a range of alternatives around the mitigation target point was not conducted. Similarly, developing multiple plans that all equated to full compensation was not common. In some cases, only one plan actually met the mitigation goals and therefore was selected as the recommended plan. If the other alternative plans did not meet the mitigation goal, and not meeting the goal was the reason cited for eliminating or not selecting the alternatives in question, it is unclear why these alternatives were fully developed and carried forward as part of the CE/ICA. This approach appears to tilt the analysis towards the desired (and selected) plan. The development of multiple plans with an output equal to the mitigation goal would eliminate this problem and lend more flexibility to the analysis. Similarly, the formulation of multiple plans with outputs that fall within a pre-determined or pre-approved range of the mitigation goal could allow better decisions, in terms of cost effectiveness, to be made.

In one study, 28 alternative plans, consisting of one management measure or a combination of several measures, were identified which met the mitigation goals. Three alternative plans having combined management measures and three alternative plans consisting of single management measures were identified as having the lowest costs per HU, and were chosen as the best potential plans. However, the three plans with combined management measures were then dropped from the analysis due to potential site unavailability and the single measure alternative plan with the lowest total cost ($2.4 million) was recommended as the selected plan. It was noted however, that the next larger plan had a total cost only slightly higher than the selected plan ($2.5 million) while providing considerably more outputs (36 HU's versus 25.9 HU's) at a much lower cost per HU ($70,139 versus $92,644). In this case, the cost effective plans were identified through the analysis of total costs and benefits, but the fact that an incremental cost analysis was not performed makes it impossible to answer whether the incremental outputs were worth the incremental costs. In this case, the critical question posed by ICA, "are 10.1 HU's worth an extra $100,000?" was never asked.

These scenarios just described negate the benefit of doing an incremental cost analysis because, in the first case, there was only one acceptable plan (that met mitigation requirements), and therefore no real increments to analyze. In the second case, the analysis was started correctly, but then cost effective solutions were dropped and the plan with the lowest total cost was chosen without regard to incremental costs or outputs.

Section 1135 Studies

Some of the problems seen in the mitigation projects were also identified with projects conducted under Section 1135 authority that were evaluated for this study. These common problems included one study that dropped three of the five best buy alternative plans because they did not meet planning objectives (according to the project report). This raises the question why the alternatives were carried forward through the CE/ICA when they did not meet planning objectives in the first place. Another problem surfaced in several studies that evaluated only total costs and outputs, rather than any consideration of increments of costs and outputs between alternatives. Since ICA by definition requires examination of changes in costs and changes in outputs between alternatives, simply looking at total costs and total outputs, without calculating incremental costs per unit of output between alternatives, is not sufficient and may bias final plan selection.

Other problems identified among 1135 studies that were not common to the mitigation studies included the case of a project which did not evaluate any costs and chose a selected plan based purely on which plan provided the maximum amount of environmental benefits. In another case, a project included five potential sites for restoration. All sites were evaluated separately, however, and it was assumed that restoration would be done at all five sites. Therefore the most cost effective combination of restoration alternatives between the sites was never evaluated. While in some cases (such as a mitigation project), it may be necessary to include all locations to ensure the proper type of habitat replacement, in this case it was not necessary (according to report documentation) to unequivocally include all five sites. The report did complete a detailed CE/ICA on each of the five project sites, however, so as a result, a cost effective or best buy solution was selected for each individual site.

In some reports, in spite of detailed explanations of the rationale for a recommended plan, aspects of the CE/ICA on which the recommendations were presumably based were flawed. For example, one project dropped three best buy plans because they did not meet planning objectives. One questions why presumably flawed plans (i.e., alternatives that did not meet planning objectives) were retained in the analysis all the way through CE/ICA. Comparing costs and outputs between the alternatives as part of CE/ICA was somewhat meaningless if the plans were to be dropped from consideration anyway due to other reasons (in this case, not meeting planning objectives). In another example from another project, only total costs and total outputs were analyzed, rather than incremental costs and outputs. Again, information related to incremental costs per unit of output, not just total costs and outputs, should be used as part of the rationale for plan selection.

The level of detail displayed in the CE/ICA for the seven 1135 projects evaluated varied greatly. The CE/ICA presented in the project reports, dated from 1995-1998, varied in complexity from something fairly detailed, with multiple restoration locations and alternatives, as well as the use of CE/ICA software; to very simple analyses, some of which could not even be classified as a CE/ICA. The output units used for the CE/ICA associated with each of the projects varied greatly as well. Two projects identified outputs as AAHU's which were obtained through the use of some combination of the Wildlife Habitat Appraisal Guide (WHAG), Aquatic Habitat Appraisal Guide (AHAG), and Habitat Evaluation Procedures (HEP). The HEP values were based on the value of a particular habitat type, rather than a specific species, in order to identify the HU's gained. Other output measures included kilograms of fish biomass, number of birds per acre, a weighted index, linear feet of uninterrupted riverine habitat, increased feeding and spawning habitat, and increased pounds of fish standing crop. This information shows that despite the often limited time and monetary constraints associated with 1135 projects, and the concerns people express regarding the required level of effort, it is possible to gather the necessary information to perform CE/ICA.

General Investigation Ecosystem Restoration Studies

Unlike the Section 1135 projects discussed, there appears to be more consistency regarding the level of detail in the GI ecosystem restoration projects. Due to the larger amounts of time and money generally allocated to this type of study, this is not unexpected. However, some of the recurring problems identified in both the mitigation and Section 1135 projects cropped up in the GI ecosystem restoration projects as well. Examples of the problems encountered include the following.

Two of the projects evaluated restoration options at multiple sites, 13 and seven sites, respectively. The sites were all evaluated separately, but the option of restoring different combinations of sites, and therefore finding the best combination of sites to restore, was not evaluated. No clear justification for why this was done was found in either report. In addition, one of the projects had two sites in which best buy plans could not physically be implemented, once again raising the question of why these plans were carried through to this point and had not been screened out earlier in the planning process. This study completely evaluated each alternative site, however, investigating between three and ten alternatives for each site. Best buy plans were selected for 11 of the 13 sites, and rationales were provided for the selection of non-best buy plans at the twelfth and thirteenth sites. In the second study however, only one or two alternatives were evaluated per site and the recommended alternatives were selected based on having the lowest cost and other criteria, rather than incremental costs and benefits. In this case, since a complete CE/ICA was neither conducted on the individual sites nor the combination of sites, plan selection may have been biased by the lack of information related to incremental costs, incremental outputs, and incremental costs per unit of output.

Another project examined only the cost per acre restored, and selected the plan with the lowest cost per acre, without examining incremental costs and benefits. This is another example where only the cost effectiveness analysis was performed, and not the incremental cost analysis, therefore not meeting the requirements of the current guidance. Another project eliminated cost effective plans from the analysis and added non-cost effective plans back in, in order to meet certain planning objectives. In another project five best buy plans were identified, only to have three of them dropped because the District did not support them. This leaves open the question why these alternatives were carried through to the CE/ICA stage in the planning process (i.e., the evaluation and comparison steps) if the District did not support them. In yet another project, CE/ICA was performed for only two of 11 possible restoration alternatives because they were the only ones to have multiple sizes. A CE/ICA between the 11 alternatives was not performed. In this case, three of the alternatives were mutually exclusive, two did not meet planning objectives, and one was found to be unfeasible from an economic and environmental standpoint. Yet another project looked only at the increase in HU's between with and without project conditions and considered this "incremental increase" to be a valid CE/ICA. These examples illustrate that many of the problems encountered during the course of conducting CE/ICA cannot be blamed on insufficient project time or resources and must be linked to some other factor.

Despite the problems related to CE/ICA discussed above, most of the analyses reviewed were quite detailed and contained a considerable amount of information pertinent to the decision-making. Five of the 15 projects used CE/ICA software and four projects investigated restoration activities at numerous different locations. Twelve of the projects used either HU's or AAHU's as project outputs. Other environmental outputs identified in the studies reviewed included: acres restored, acid load reduction, number of salmon per year returned to river, and increase in bottomland hardwood values.

Use of Software in Project Reports

As discussed earlier, IWR has developed a CE/ICA software program (IWR-PLAN Decision Support Software, and its predecessor, ECO-EASY) to be used as a tool to assist in plan formulation and evaluation. IWR-PLAN helps users formulate alternative plans by combining management measures according to user-specified dependency and combinability relationships. The software assists in plan evaluation and comparison by conducting cost effectiveness and incremental cost analyses, identifying the plans that are the best financial investments, and displaying the effects of each plan on a range of decision variables. While endorsing or advocating use of IWR-PLAN or a similar tool was not one of the objectives of this report, the desire to determine whether additional guidance, training, or tools, for example, could help the CE/ICA process, was an intended objective. In order to do this, it was necessary to look at the available tools to see if, and how, they are being utilized and if their use aids in meeting the CE/ICA requirements.

Eight out of 26 (31%) of the projects utilized ECO-EASY or IWR-PLAN to complete the CE/ICA requirements. These were the only two decision making software packages utilized in the projects reviewed. The highest percentage of use was found in mitigation projects in which 40% of the projects reviewed utilized CE/ICA software. The Section 1135 projects showed the lowest use (29%) while the GI studies fell in the middle with 33%. Due to the small sample size associated with this report and the relatively small differences between the software utilization by project type (11%), it is not possible to make any conclusions as to whether software is being consistently used more frequently for one project type than another. In addition, despite the fact that the reports reviewed were developed between 1994 and 1999, the use of CE/ICA software was only found in projects beginning in 1997, with the largest percentage found in projects completed in 1998 and 1999. This is not entirely surprising however since the IWR software was not available until 1995. Depending upon the completion dates of the specific projects reviewed, this fact could also have affected the above percentages. This recent trend of using CE/ICA software may be due to an increased familiarity with the software (and its availability), the increased capabilities of the software, or simply an increase in the number of projects being completed (i.e., ecosystem restoration and mitigation) that would require the completion of a CE/ICA. This is not to say however, that all projects completed during this time frame (1997 to present) utilized either ECO-EASY or IWR-PLAN. In fact, of the 16 reports reviewed which were developed within this time period, half used software while the other half did not.

A connection can be suggested, however, between the use of the software and the identification of a selected plan that was either a cost effective or best buy alternative. As stated earlier, 54% of the projects reviewed for this effort indicated that the selected plan was either a cost effective or best buy alternative. Fifty-seven percent of the cost effective or best buy plans selected were identified with the assistance of a software tool. More importantly however, is the fact that in the projects where software was utilized, a cost effective or best buy alternative was chosen as the selected plan 100% of the time. Since a primary goal of completing a CE/ICA is to choose a cost effective plan and enjoy the greatest environmental return for the financial investment expended, it appears that the use of software may help in achieving that goal.

Personal Interviews

In an attempt to identify problems relating to CE/ICA that may not have been evident during the review of the analyses, personal interviews were conducted with several Corps employees who had conducted CE/ICA. Interestingly, the comments, problems, and concerns raised during these interviews were very similar to responses gathered during two previous efforts on the subject of ecosystem restoration and mitigation planning, which involved information gathering and interviews with Corps employees. The first such effort culminated in a document entitled, "Effectiveness of Incremental Analysis in Fish and Wildlife Mitigation Planning – Results of 1989 Survey of FOA's" (Reece, 1989). The purpose of this questionnaire was to measure the effectiveness and consistency of field offices (FOA's) application of incremental cost analysis (ICA). Some general comments about incremental cost analysis that were common among several respondents include the following:

- Practitioners need more training (this was the most common response).
- ICA is a useful tool, but not an "end all". Other factors may be more important.
- ICA is not always applicable.
- Costs should not be an overriding factor in mitigation planning.
- There is a need for consistency between engineering, economic, and environmental analysis.

The second effort, "Compilation and Review of Completed Restoration and Mitigation Studies in Developing an Evaluation Framework for Environmental Resources, Volume I," was a data gathering effort that focused on identifying the important planning issues being faced by Corps planners as well as the issues that needed attention in environmental project plan formulation and evaluation (U.S. Army Corps of Engineers, 1995). This report expressed the notion that, at the time of the report, incremental cost analyses were reluctantly utilized by Corps Districts, and, in many cases, were utilized mainly to appease Headquarters. Other general comments expressed on the subject of ICA during the course of this effort included the following:

- Incremental cost analysis is a useful tool for the planning process, but it should be recognized as one of many elements in the final decision.
- There is significant difficulty in applying incremental cost analysis with regard to determining appropriate components for conducting an analysis and the level of analysis to be conducted for small-sized projects.
- Communicating the results of ICA can be difficult, especially to individuals representing local interests.
- ICA assumes there is a wide array of options to examine, but for mitigation projects, these options are limited.

Since the time of these investigations, several steps have been taken to address the problems and difficulties perceived with regard to the CE/ICA process. Updated software, in the form of IWR-PLAN, has been developed and released which has the capacity to aid in simplifying the steps and the documentation of the analyses. Training has been implemented which addresses the use and applications of the software. Additional training, in the form of Corps short courses, incorporates the software training with overall information relating to environmental restoration planning and evaluation techniques. Despite these steps however, many similar issues were still raised during the current interview effort.

All of the people interviewed for this report were in the field of biology or biological sciences, had a minimum of seven years of experience with the Corps, and had personally completed or been involved in one to five CE/ICA procedures. The names of the individuals who had conducted the analyses were obtained from the project reports reviewed for this effort. The interview questions focused on problems encountered during the analyses, how the CE/ICA was used during the project, the individuals' views on CE/ICA as relevant to plan evaluation, and the individuals' discipline and length of Corps experience. In addition, discussions were held regarding the future needs and direction of guidance, tools and training, and what they thought would be most useful to aid them in future CE/ICA applications. Comments from Corps practitioners of CE/ICA generally fell into four categories: 1) problems/difficulties encountered during the course of conducting CE/ICA; 2) experience with CE/ICA software; 3) general impressions of CE/ICA procedures; and 4) recommendations related to training, tools, or guidance needs.

According to the respondents, some of the problems or difficulties encountered when conducting CE/ICA procedures include:

- Developing the (incremental) costs associated with mitigation alternatives.
- Obtaining incremental plan costs from cost estimators.
- Combining HEP outputs when more than one species is involved.
- (Corps) management trying to control the development and direction of alternatives and the CE/ICA.
- Good guidelines are not available regarding how to do CE/ICA.

- Project information needed to perform analyses is not always available.
- Predicting future conditions.
- Justifying smaller projects with smaller habitat unit outputs.
- Development of data needed for the analysis, rather than the analysis itself.

Comments from interviewees reflecting their experiences using CE/ICA software include:

- The software is helpful but seems to be geared more towards doing ecosystem restoration rather than mitigation.
- The DOS version of the software (ECO-EASY) was slow, which made it necessary to break the analyses down into smaller parcels.
- The tables of results produced by software are helpful.
- The ability of IWR-PLAN to address multiple outputs is useful.
- The ability to optimize a reduction in HU's (impact assessment), rather than an increase, would be advantageous.
- ECO-EASY has been helpful in evaluating multiple levels and combinations of alternatives.

Some of the unfavorable impressions of CE/ICA procedures reported by respondents include:

- There is a perception in the Corps and other agencies that CE/ICA is a way to justify the avoidance of fully mitigating for project impacts.
- CE/ICA is often extra paperwork done in order to meet requirements, but it could be a valuable tool.
- CE/ICA may be more useful and appropriate for environmental restoration projects, rather than for mitigation.
- There needs to be more flexibility in not forcing the analysis on the Districts in cases where the analysis may not be appropriate.
- CE/ICA is just a requirement and not a good tool and should be replaced with something else.
- The CE/ICA process should be simplified.

On the other hand, favorable comments about CE/ICA procedures reported by respondents include:

- CE/ICA is a good tool to demonstrate the differences between different alternatives and their benefits.
- CE/ICA is a useful tool that is worth the effort. It also demonstrates that the Corps has put thought and effort into the analyses.

- CE/ICA is a good tool to help get through the process and take the subjectivity out of the decision making process.
- The Prospect course on benefit evaluation techniques was helpful with regard to explaining the analyses.
- CE/ICA is the best tool available for tying the environment outputs into projects.
- Once the analysis is complete and tables have been developed, one can still make the decision regarding the recommended plan, rather than having only one plan identified by the software.

Some of the recommendations related to training tools or the need for guidance reported by respondents include:

- Updated examples (case studies) illustrating the use of CE/ICA for mitigation, ecosystem restoration and Section 1135 projects.
- The ability to compare different sites (i.e., real estate) in order to acknowledge differences such as cost per acre to acquire land in the analyses.
- Electronic updates to IWR-PLAN users when software upgrades become available.
- Additional training (on the software and on the process of performing a CE/ICA).
- An updated manual which illustrates the CE/ICA procedures.
- More information and training on the new IWR-PLAN software.
- Better outreach to inform people of new software and upgrades.
- A better understanding of other tools that could be used to justify mitigation projects if CE/ICA is not used.
- Guidance on the interpretation of results to help justify the choice of the selected plan when there is not a big difference in the output of the various plans.
- Found training on CE/ICA given at District by IWR to be very helpful. Recommends this type of training for all Districts involved in the use of CE/ICA.

The individuals surveyed used the analyses in both the plan formulation and decision making phases of the project, depending upon the type of project and the complexity of the project. Overall, most of the people contacted were in favor of doing CE/ICA and saw the benefits associated with the analyses. These same people seemed more comfortable with the principles behind the analyses as well as the results that they obtained from them. The individuals were generally in agreement that more training and updated case studies or examples of different project types would aid them in future analyses.

It is evident that the results of the 1989 and 1995 investigations yielded concerns and problems very similar to the issues presently raised. The need for training, however, appears to be foremost on people's minds. Suggested training methods in the 1989 study included discussions, workshops, and seminars. Similarly, the results of the 1995 effort recommended conducting training and workshops on the purpose, intent, and mechanics of incremental cost analysis.

CONCLUSIONS AND LESSONS LEARNED

Overall, it appears that the practice of conducting CE/ICA is fairly widespread throughout the Corps. Only six of the 32 ecosystem restoration and mitigation reports reviewed did not address CE/ICA at all. In at least one of those cases, it was documented that the HQUSACE supported this decision. Among the remaining 26 reports, three reports had little more than a section heading and a paragraph or two that composed the "incremental cost analysis" for that project. In addition, another eight reports were found to have incomplete or flawed analyses. An analysis was deemed incomplete if, for example, only a cost effectiveness analysis was done, or if only total costs, rather than incremental costs, were examined. The review of these project reports has provided valuable insight into how CE/ICA are being done throughout the Corps.

It is now time to address the question posed at the beginning of this investigation, "What lessons have we in the Corps learned from performing cost effectiveness and incremental cost analyses over the last decade?" One thing that has been learned is that there still exists a certain amount of confusion, uncertainty, and even, in some cases, reluctance towards the CE/ICA procedures. These attitudes can manifest as problems in many areas of the CE/ICA, the most common being the lack of understanding regarding what actually constitutes a CE/ICA. On the other hand, however, many good examples of CE/ICA were also identified, indicating that this confusion is far from universal, and that the CE/ICA procedures can work effectively when planning and evaluating Corps projects. The following "Observations" and "Lessons Learned" summarize what the authors of this report learned about the application of CE/ICA procedures within the Corps from reviewing project reports and interviewing CE/ICA practitioners.

Observation (1):

On the subject of the applicability of CE/ICA to Corps projects, there seems to be a perception that the CE/ICA procedures are easier to apply to ecosystem restoration projects, rather than mitigation projects. One of the reasons for this is that many mitigation studies have targets in terms of the amount of environmental or ecological resources to be restored (in terms of habitat units or acres, for example), as well as the type of resource and/or habitat being restored. Other Federal and State resource agencies often specify these targets, which are linked to project impacts that could not be avoided or minimized. For some planners, CE/ICA is more difficult to perform when the formulation of multiple mitigation alternatives or scales of alternatives appears to be constrained by the need to meet a target. This was seen in several projects reviewed in which alternatives that did not meet mitigation targets were included in the CE/ICA, only to be dropped at the end of the analysis because they did not meet the stated targets. In several cases, only one alternative actually met the mitigation planning objective and was therefore selected as the recommended plan.

Lesson Learned (1):

CE/ICA can be used to inform mitigation investment decision-making just as it informs ecosystem restoration decision-making. First, it may be possible to develop multiple alternatives to meet the mitigation target. Cost effectiveness analysis (CEA) can identify the least cost option for meeting the target. Second, if multiple alternatives and scales (e.g., sizes) of alternatives can be developed, it may be possible, depending on the shape of the cost effectiveness frontier, to justify an alternative that exceeds the target but costs very little more than the alternative that only just meets the target. Conversely, the results of CEA may indicate that meeting the target is prohibitively expensive, but that a slightly smaller alternative can meet most of the target at a considerably lesser cost. In this case, the intent of CE/ICA is not to argue for less than full mitigation, but to highlight the potentially expensive nature of "final units". Either way, CE/ICA can illuminate what is being lost or gained (both monetarily and environmentally) in selecting a given alternative versus an alternative that just meets the mitigation target. Obviously, the formulation of multiple means (alternatives) of meeting a mitigation target, as well as developing other alternatives with levels of output below or above the target, improves the quality of the information available to recommend a particular mitigation plan.

Observation (2):

The situation was also identified in several ecosystem restoration projects in which alternative plans that did not meet planning objectives were carried through the planning process, up to and including CE/ICA and identification of best buy plans, only to be eliminated at the point of plan selection.

Lesson Learned (2):

This practice skews the CE/ICA and its results, and often indicates that the problems are related to the identification of the planning objectives as well as the identification and formulation of plans that meet those objectives, rather than with the CE/ICA analysis itself. In cases such as these (at least for the studies reviewed for this report), any of the alternative plans identified would have resulted in "beneficial" restoration projects (i.e., positive environmental benefits). However, the goals that were adopted at the beginning of the study were either too limiting (e.g., a goal of maximizing environmental outputs) or based on factors unrelated to the analysis (e.g., incidental benefits) which severely limited the analysis and the number of alternatives that could support the planning objectives. In these situations, plans that do not meet planning objectives should be dropped from the analysis at an early stage in order to ensure that adequate time and resources can be spent developing implementable plans.

Observation (3):

Another problem identified that indicates that the concepts of CE/ICA are not always understood relates to the tendency to select a plan because it provides the "greatest environmental output" or, conversely, is the "least expensive".

Lesson Learned (3):

While it is acceptable to ultimately choose the plan with the largest output or lowest cost, these reasons should not be the only decision-making criteria. Incremental costs and benefits must be evaluated to help make the decision as to whether or not the extra increment is worth the difference (in either cost or outputs) between it and the next smallest alternative. The results of this analysis, together with a documented assessment of the significance and scarcity of the resources the project is trying to improve, among other criteria, will help to answer the question, "Is it worth it?"

Observation (4):

The tendency to select the largest plan (i.e., greatest environmental output) was also evident in several situations involving multiple restoration sites. Several projects applied seemingly unnecessary (and unexplained) dependencies[6] to the sites and did not evaluate the possibility of not restoring all sites. This guaranteed that the largest plan (i.e., the plan that restored all sites) was chosen as the selected plan.

Lesson Learned (4):

While there is nothing wrong with selecting the largest alternative, and the regulations do not specifically require that multiple sites be evaluated together, there is no way of knowing whether the best, and most cost effective, combination of sites was chosen since the option of not restoring all sites was never evaluated. In this case, the question, "Is it worth it?" to go to the next level (i.e., include the next site) was neither asked nor answered. In cases where the number of sites restored for a specific project is politically (e.g., sponsor) driven, the Locally Preferred Plan (LPP)[7] is always an option for recommendation. Even so, the project delivery team must strive to ensure that, at a minimum, a cost effective solution for each site is chosen, and the selection of the LPP must still be properly justified and documented. This requires having multiple viable alternatives for each site that can be used to complete a CE/ICA, since in this special

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[6] A dependency is a situation in which solutions or management measures are dependent upon each other (i.e., one cannot be successfully implemented without the implementation of the other).

[7] The concept of the Locally Preferred Plan (LPP) for ecosystem restoration projects is described in ER 1105-2-100, paragraphs 4-3b (2) (a) and (b). In general, the local sponsor would pay the difference in cost between what the project delivery team and decision-makers have determined to be the National Ecosystem Restoration (NER) Plan and the locally preferred alternative, provided that the outputs of the LPP are similar in-kind and equal to or greater than the outputs of the Federal NER plan, and provided that an exception to the NER plan is granted by the ASA(CW) .

situation the analyses may not be conducted between sites. In addition, there should be good, ecosystem-based reasons for the inclusion of all sites.

Observation (5):

As previously stated, many problems encountered during CE/ICA are not directly related to the mechanics of the procedures or the characteristics of the particular plan chosen for implementation, but rather whether the CE/ICA results are used and what other information is provided in terms of the rationale for plan selection. This problem can be characterized as difficulty in "telling the story;" in this case, the "story" of plan selection. While some of the reports reviewed offered compelling explanations for why a particular plan was selected, several were lacking in terms of "telling the story" and explaining the project's deviation from the results of the CE/ICA procedures.

Lesson Learned (5):

The selected plan does not in all cases have to be a best buy plan, or even cost effective (though this is strongly encouraged in ER 1105-2-100), as long as the rationale for selecting a non-cost effective or non-best buy plan is clearly discussed and documented. Factors such as constraints, dependencies, multiple scales, and the applicability to planning objectives must be evaluated early in the analysis and must be thoroughly explained. Explicit descriptions and explanations of the rationale behind the selection of the plan, and the steps taken to get to that point, must be included as part of any CE/ICA, especially if they are driven by reasons other than the CE/ICA results (for example, sponsor's goals, planning objectives, environmental constraints, or financial constraints). This will not only help to ensure that the analysis does not get to a point where it is necessary to drop cost effective or best buy plans in order to meet planning objectives, but will also help to justify the plan selection. This is especially important if the selected plan was not a best buy or cost effective solution. If compelling reasons exist for the selection of this plan, based on the significance or scarcity of the resource, or other criteria such as completeness, acceptability, or effectiveness, it must be properly documented in order to justify the plan selection.

One way to help "tell the story" is the use of software such as IWR-PLAN. Discussions with individuals, as well as the review of reports where the software was used, indicates that using the software does help to document the CE/ICA process. Software use has been more prevalent over the last few years and has been viewed by many as a valuable tool. In terms of improving the analysis, it was noted that 100% of the reports that utilized the software chose either a cost effective or best buy plan for implementation. In addition, the software was helpful in terms of "telling the story" through the use of tables and graphs to relate results and conclusions. A full description of IWR-PLAN is included in Appendix B.

Summary of Lessons Learned

Overall, CE/ICA can be a valuable tool with the potential to improve the planning process for environmental restoration and mitigation projects. Unfortunately, however, despite that fact that the Corps has been involved in these analyses for several years, there is still a lot of room for improvement and standardization of the analyses. Some of the specific "lessons learned" gathered during this effort are summarized below.

1. The perception exists that CE/ICA may, in some cases, be more applicable to ecosystem restoration projects than mitigation projects. The fact of the matter, however, is that CE/ICA should be used to inform mitigation planning by demonstrating the cost effectiveness of various alternatives that meet a mitigation target, as well as the cost savings or benefits gained of alternative plans that provide greater or lesser ecosystem outputs than the mitigation target.
2. Not enough emphasis is being placed on defining reasonable planning objectives and formulating plans that will meet those objectives. The formulation of multiple viable alternatives that meet the planning objectives of the ecosystem restoration or mitigation project is not being accomplished in all studies. More than one alternative plan that meets the defined goals and objectives should be formulated in order to properly conduct the analyses.
3. CE/ICA is not performed in all cases (even when some analyses are mislabeled "CE/ICA"). Some analyses evaluate only the total costs and benefits, not the incremental costs and benefits, therefore not completing the analyses or asking the question, "Is the incremental environmental output worth the incremental cost incurred to achieve it?"
4. When multiple restoration sites are proposed, there exists a tendency to include restoration activities at all sites, rather than asking whether it is worth it to restore all sites. In this situation, all sites should be evaluated as separate components of a single plan unless compelling reasons exist to include restoration at all sites. At a minimum, a complete CE/ICA needs to be completed for each site that results in the selection of a cost effective solution for each area. Recommendation of a Locally Preferred Plan is always an option when political considerations drive the analysis towards the inclusion of all sites.
5. The practice of "telling the story" through discussing the CE/ICA procedures, results, and rationale for the selected plan is not being adequately documented in many reports. Explaining the results of CE/ICA, as well as information related to how well an alternative plan meets planning objectives, addresses significant resources, and meets acceptability, completeness, effectiveness, and efficiency criteria, among others, are integral parts of "telling the plan selection story." To that end, decision support software can support the CE/ICA procedures. The use of graphs and tables produced by the software is helpful in relating CE/ICA information.

RECOMMENDATIONS

In reviewing documents and interviewing CE/ICA practitioners for this report, two major needs tended to surface: the need for additional training and the need for current examples (i.e., case studies) of successful applications of CE/ICA. While training focusing on the use and application of such CE/ICA software as ECO-EASY and IWR-PLAN has been offered for several years, the desire was expressed, and the need seemingly confirmed in the content of report documentation, that additional training be provided. Rather than focusing solely on the software, the suggested training would address such fundamental planning-oriented topics as developing planning objectives, significance of ecosystem resources, plan formulation, selection of evaluation methodologies, quantification of ecosystem outputs, and criteria for plan selection. As cited in this report, many of the problems encountered with CE/ICA were actually manifestations of problems introduced earlier in the planning process (for example, not having enough alternatives on which to perform a meaningful CE/ICA because alternatives had been formulated that did not meet planning objectives, but had not been removed from consideration).

A current initiative that promises to address this need for training, and indeed has already begun to do so, is the Civil Works Planning Capabilities Initiative, championed by the Chief of Civil Works Planning and Policy Division. Several activities of the Planning Capabilities Initiative, most notably the Planning Core Curriculum, focus on developing basic and expert planning skills. Several modules of the Core Curriculum, including the Planning Process, Plan Formulation, Economic Analysis, and Environmental Considerations workshops, cover such topics as developing planning objectives, methods of plan formulation and development of a sufficient number of alternatives, evaluation methods, the information required and how to perform CE/ICA, and decision criteria considerations. The fact that the training workshops are being conducted at the District or Division level makes them all the more effective, allowing participants to focus on relevant and familiar examples and providing the opportunity for brainstorming and special assistance on current projects. Thus, the Corps appears to tackling this training challenge aggressively.

The second major need, that of current case studies, was primarily identified through the interview of Corps personnel. With the changing technology, guidance, and types of projects being conducted by the Corps, it was suggested that current examples of completed analyses would be beneficial to aid in the completion of future projects. Such case studies could demonstrate how the CE/ICA was completed, perhaps covering different ways of approaching the analysis and different degrees of complexity.

Fortunately, this need appears to be met at least partially through the exchange of information on ongoing ecosystem restoration studies occurring at the Planner's Resource website (www.iwr.usace.army.mil/iwr/plannersweb/index.htm), the Planning Ahead newsletter, and such venues as the Corps' Economic and Environmental Analysis

Conference 2002. While these information sources may not cover CE/ICA "case studies" per se, they do highlight how CE/ICA is being performed, and highlight successful applications, for various ecosystem restoration projects throughout the Corps.

In terms of recommendations for the individuals actually responsible for performing CE/ICA and using the information to assist in plan selection, the authors of this report offer three simple words: "Tell the story." The importance of documenting the rationale behind the choice of the selected plan cannot be emphasized enough. Using tables, graphs, maps, chronology, and other means helps to "tell the story" well. Many of the reports reviewed made it extremely difficult to even determine what the selected plan was, let alone why it was selected. This is especially important if a plan is selected that is not a cost effective or best buy plan. Reasons for choosing the plan should be shared with the reader and reviewer.[8] Part of telling the story is answering the "Is it worth it?" question convincingly. Recommending a particular ecosystem restoration plan requires that we explain why a given level of environmental resource or ecosystem service is worth the investment required to achieve it.

CE/ICA is designed to be a tool to help guide decision-makers towards making good financial investments. It is but one tool, however, to support sound planning techniques in the areas of ecosystem restoration and environmental mitigation. The results of CE/ICA, along with information related to the significance of the associated environmental outputs, as well as the completeness, efficiency, effectiveness, and acceptability of the alternative plans, are all important and necessary criteria in selecting the recommended ecosystem restoration plan.

[8] As an illustration of this point, in discussions with members of the Headquarters Policy Review Branch in preparing this report, reviewers mentioned that during the review of ecosystem restoration reports they look to see if a CE/ICA was conducted, whether various management measures were considered in the formulation of alternative plans, whether the CE/ICA is complete, that it makes sense, and that it is easy to understand.

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APPENDIX A

DOCUMENT REVIEW QUESTIONNAIRE

Document Review Questionnaire

Report Title:	**Report Date:**
Organization/District:	**Type of Project:**
POC:	**Cost of Selected Plan:**
ICA Model Used?: Yes No	**If So, Which One?:**
Level of Detail: High Med Low	**# of Mgmt Measures:**
Cost Unit:	**Output Unit(s):**
# of Outputs (Selected Plan):	**Dependencies?:** Yes No
Non-Combinabilities?: Yes No	**# of Combinations:**
Cost Effective Graph?: Yes No	**Best Buy Graph?:** Yes No
# of Cost Effective and Best Buy Combos:	
Were Alternatives Combined? Yes No	
Were Mgmt Measures Constrained by Project Location?: Yes No	
Was Selected Plan the Cost Effective or Best Buy Plan?: Yes No	
Reason for Recommendation of Selected Plan:	
Good Project for a Case Study? Yes No	
NOTES:	

APPENDIX B

EXISTING CORPS SOFTWARE TOOLS AVAILABLE TO FACILITATE CE/ICA

EXISTING CORPS SOFTWARE TOOLS AVAILABLE TO FACILITATE CE/ICA

The results of this report indicate that there may be a significant benefit to using some form of software to complete cost effectiveness and incremental cost analyses (CE/ICA). In addition, it also appears that information regarding the existence and usefulness of existing Corps tools has not always been thoroughly disseminated throughout the Corps network. For this reason, information on IWR-PLAN is provided in the following paragraphs in an effort to expose the readers to information regarding the availability and capabilities of this tool.

As stated earlier in this document, the Corps' Institute for Water Resources (IWR) has developed procedures for conducting CE/ICAs for ecosystem restoration planning studies. These procedures can be used to formulate alternative plans, identify which of those plans are cost effective, and conduct incremental cost analyses. The results of the analyses help planners and decision makers address the question "how much environmental benefit is worth its cost?" These procedures have been incorporated into computer software to assist in plan formulation and in conducting CE/ICA on alternative plans. The first-generation, DOS-based program, called ECO-EASY, was released by IWR and the Corps Waterways Experiment Station (WES) in 1995. Under the Corps' Decision Support Technologies Research Program, ECO-EASY was updated into the current Windows-based operating environment. The most recent version, IWR-PLAN Decision Support Software Version 3.3, was released in June 2001. IWR-PLAN builds upon the basic plan formulation and comparison framework of ECO-EASY, but expands the software's capabilities in many important ways.

Use of either ECO-EASY or IWR-PLAN requires the input of three types of data: a list of solutions, and for each solution, estimates of its environmental effects ("output" estimates, for example, habitat units, acres, stream miles) and of its costs. The software then allows the user to conduct three processing functions: *formulation* of plan combinations consisting of up to 26 solutions (e.g., either individual management measures or full-blown alternatives), *cost effectiveness analysis* of plan combinations, and *incremental cost analysis* of cost effective plan combinations. Every possible combination of solutions is derived and a total cost and total output estimate is calculated for each combination. The program then conducts cost effectiveness analysis; first identifying the least cost combination for every possible level of output, and then identifying the cost effective set of combinations by screening out plans in which more output could be provided by another combination at the same or less cost. Once the cost effective set of combinations is identified, the program calculates the incremental cost and incremental output of moving from each combination to the next larger combination. IWR-PLAN identifies the subset of the cost effective that are most efficient in production, called the "best buys", as scale increases from the smallest to the largest combination. The best buy plans have the lowest incremental costs per unit of output, or, stated another way, the greatest increases in output for the least increases in costs.

A variety of graphing and reporting options are available to aid in the decision making and data presentation, and include choices of line or bar graphs. The following graphs may be displayed: all plan combinations, all plans differentiated, cost effective plans, cost effective plans differentiated, and best buy plans. Some new features include examining the trade-offs between plans is facilitated by the ability to run the CE/ICA on one output variable (e.g., aquatic habitat), while displaying the effects of cost effective and best buy plans on another output variable (e.g., terrestrial habitat). Reports containing tabular displays of total cost, total output, incremental cost, incremental output, average cost, and incremental cost per unit of output can also be produced. All graphs and data in an IWR-PLAN file are directly exportable to a range of other programs to assist with reporting. To speed data entry, data may be imported from Excel spreadsheets. The program also comes with an on-screen help system which provides instruction for all forms and functions in the program. The latest version of IWR-PLAN includes a "Walk-Through" mode for new users, as well as those interested in performing only a basic analysis.

For more detailed analyses, the program can formulate alternative combinations with each solution having up to 20 mutually-exclusive scales (different levels or sizes of each solution). The program adds up and compares the combination of solutions' effects on up to ten user-specified decision parameters (e.g., one cost variable and nine different output variables). "Derived" parameters can be defined that are combinations of other decision variables. This allows multiple output metrics (e.g., habitat units for different kinds of species) to be used to run the CE/ICA. Constraints can be set, specifying minimum and maximum acceptable values for each decision variable (e.g., cost limits and output targets). IWR-PLAN's sensitivity capability allows examination of the implications of uncertainty in decision variable estimates. For example, the analyses may be re-run with 20 percent higher costs, or 30 percent lower output values, to investigate differences in results. "Plans of interest," particular plans that the study team wishes to identify and track throughout the analyses, regardless of their cost effectiveness, can be labeled. The "automated editing" feature enables users to account for non-additive plan effects, such as might occur when two solutions work synergistically to yield greater outputs than the sum of the two employed separately.

Additional capabilities include the ability to create multiple scenarios from one set of input data. Scenarios may differ as to what decision variables are included in the cost effectiveness analyses, what solutions are included, what sensitivity values are used, what constraints are applied, what plans of interest are included, and whether automated edits are applied. The results from different scenarios can be compared through IWR-PLAN's multiple scenario comparison module.

IWR-PLAN is available to download free of charge via the IWR-PLAN web site (http://www.iwr.usace.army.mil), then click on "Products", then "IWR-PLAN". The IWR-PLAN web site also provides operating instructions, Frequently Asked Questions, tutorial exercises, and a news board for announcing program developments, such as upgrades. The software is also available on CD from IWR. Questions regarding the software should be directed to the software program manager, Mr. Leigh Skaggs, at 703-428-9091.